CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-123

July 8, 1981

1. Name and location of fault.

Maacama fault, Willits SE and Redwood Valley quadrangles, Mendocino County, California (see Figure 1).

2. Reason for evaluation.

Part of a state-wide program to zone active faults (see Hart, 1980). Traces to the north and south are in the process of being zoned (California Division of Mines and Geology 1981a; 1981b).

3. List of references.

California Division of Mines and Geology, 1981a, Preliminary map of Special Studies Zones, Ukiah quadrangle.

California Division of Mines and Geology, 1981b, Preliminary map of Special Studies Zones, Willits NE quadrangle.

Dames and Moore, 1977, Final Report, Maacama microearthquake survey, in Maacama fault study, Sonoma and Mendocino Counties, California: U.S. Army Corps of Engineers, San Francisco District, Appendix CE-3.

Gealey, W.K., 1951, Geology of the Healdsburg quadrangle, California: California Division of Mines Bulletin 161, p. 7-50.

Harding-Lawson Associates, 1977a, Maacama/Talmage fault study, review of maps and bibliography, in Maacama fault study, Sonoma and Mendocino Counties, California: U.S. Army Corps of Engineers, San Francisco District, Appendix CE-2.

Harding-Lawson Associates, 1977b, Recently active breaks along the Talmage fault zone, Mendocino, County, California, in Maacama fault study, Sonoma and Mendocino Counties, California: U.S. Army Corps of Engineers, San Francisco District, Appendix CE-1.

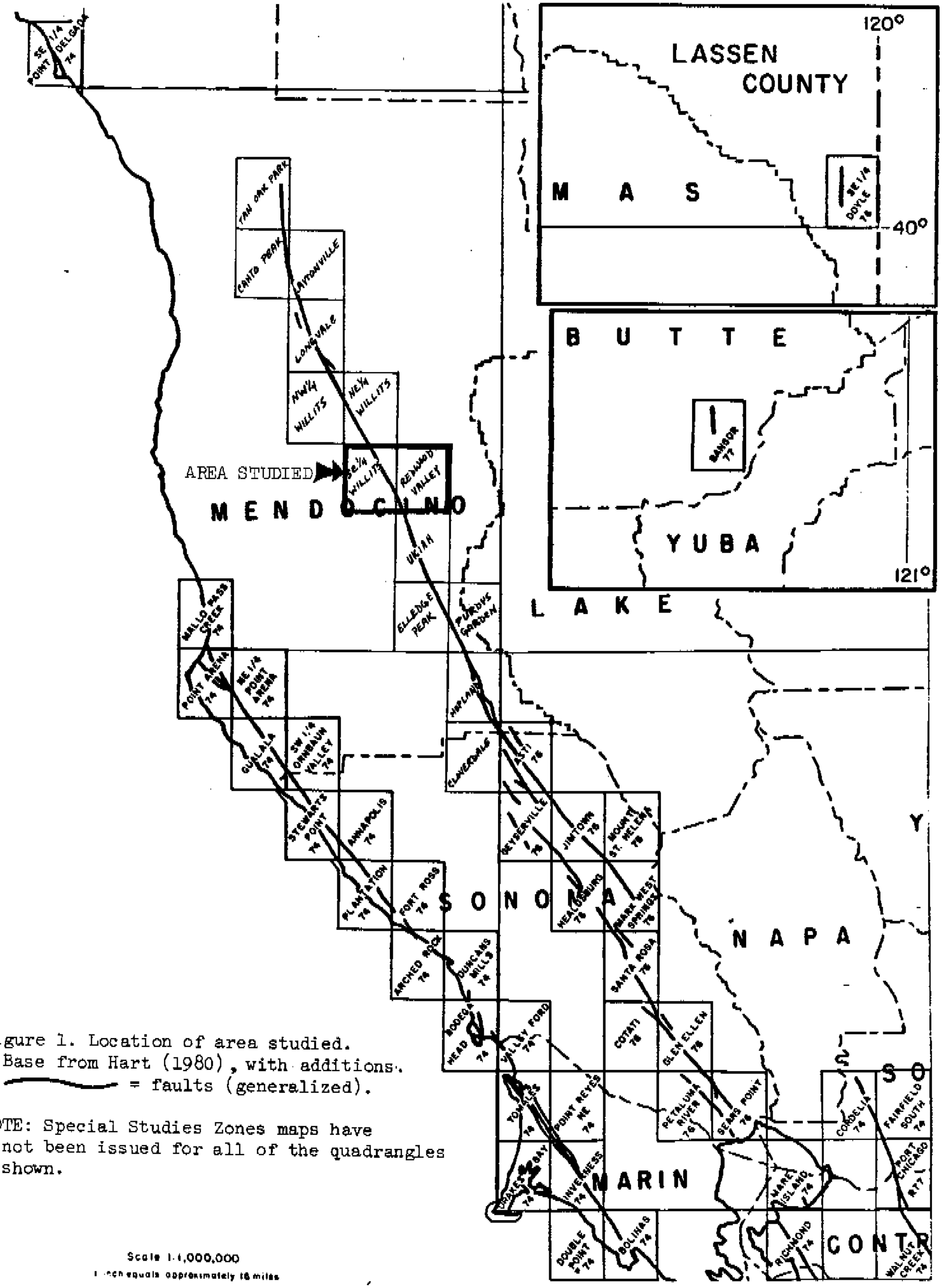

Figure 1. Location of area studied.
Base from Hart (1980), with additions.
——— = faults (generalized).

NOTE: Special Studies Zones maps have not been issued for all of the quadrangles shown.

Harsh, P.W., Pampeyan, E.H., and Oakley, J.M., 1978, Creep on the Willits fault, California (abs.): Seismological Society of America Earthquake Notes, v. 49, n. 1, p. 22.

Hart, E.W., 1980, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Publication 42.

Herd, Darrel G., 1978, Intracontinential plate boundary east of Cape Mendocino, California: Geology, v. 6, p. 721-725.

Jennings, C.W., 1975, Fault maps of California with location of volcanoes, thermal springs, and thermal wells: California Division of Mines and Geology, Geologic Data Map No. 1, 1:750,000 scale.

Jennings, C.W., and Strand, R.G., 1960, Ukiah sheet: California Division of Mines, Geologic Map of California, Olaf P. Jenkins Edition, 1:250,000 scale.

National Aeronautics and Space Administration, 1972, U-2 flight 72-119B, infra-red (false color) aerial photographs (510-900 nm spectral band), scale approximately 1:130,000, frames 1635-1641.

Pampeyan, E.H., Harsh, P.W., and Coakley, J.W., 1980, Preliminary map showing recently active breaks along the Maacama fault zone between Laytonville and Hopland, Mendocino County, California: U.S. Geological Survey Open-File Report 80-662.

Pampeyan, E.H., Harsh, P.W., and Coakley, J.W., 1981, Preliminary map showing recently active breaks along the Maacama fault, zone between Laytonville and Hopland, Mendocino County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1217.

Simon, R.B., E.H. Pampeyan, and C.W. Stover, 1978, The Willits, California, magnetude-4.8 earthquake of November 22, 1977: U.S. Geological Survey Open-File Report 78-1075.

Smith, T.C., 1981, Maacama fault, area of reported historic rupture: California Division of Mines and Geology Fault Evaluation Report FER-111 (unpublished, on file in the San Francisco District Office).

U.S. Army Engineer Corps of Engineers, San Francisco District, 1978, Maacama fault study, Sonoma and Mendocino Counties, California.

Upp, R.R., 1981, Map of the Maacama fault zone (preliminary) with Appendix A, in Holocene activity on the Maacama fault: Stanford University, PhD thesis, work in progress (map filed with CDMG, San Francisco District Office).

U.S. Department of Agriculture, 1963, Black and white aerial photographs, scale approximately 1:24,000, Flight CVN, numbers 3DD 14 to 17, 4DD 62 to 71, 7DD 13 to 20 and 130 to 136, and 8DD 76 to 80.

4. Summary of available data.

The Maacama fault zone consists of a series of right-lateral faults along which movement has occurred during Holocene time (Harding-Lawson and Associates 1977a; Pampeyan, et al., 1981; Upp, 1981). Herd (1978) has suggested that the Maacama fault zone is part of a larger system of faults, the Hayward-Lake Mountain fault system, which bounds the Humboldt and North American plates. According to Herd, the Maacama is connected to the San Andreas fault system via the Rogers Creek-Healdsburg, Hayward, and Calaveras faults to the south.

Gealey (1951) named the Maacama fault zone and cited evidence of recent movement near Healdsburg, about 40 miles south of the area studied herein. Almost none of the geology of Mendocino County has been mapped in detail. Neither the most detailed geologic map of the area (Jennings and Strand, 1960) nor the Fault Map of California (Jennings, 1975) show any of the faults evaluated herein.

In January, 1978, the U.S. Army Corps of Engineers released a study of the Maacama fault. Within the Corps' report were three other reports (Dames and Moore, 1977; Harding-Lawson Associates, 1977a and 1977b). To delineate the Maacama fault (which they called the Talmage fault), Harding-Lawson Associates primarily relied on aerial photo interpretation, literature research, and limited field reconnaisance. The primary objective of the Corps' study, and the Harding-Lawson study, was to determine the overall length of the active Maacama fault so that the maxium credible earthquake could be estimated. The fault traces delineated by Harding-Lawson Associates appear to be generalized and have not been plotted on the accompanying maps.

After the Harding-Lawson Associates and Dames and Moore studies were completed, a 4.8-magn tude earthquake occurred near Willits. During the post-earthquake investigations, Harsh detected evidence of fault creep in downtown Willits north of the area studied herein (Simon, et al., 1978). Subsequently, quite convincing evidence of fault creep has been documented near Ukiah, to the south, as well as in Willits (Harsh, et al., 1978; Pampeyan, et al., 1980 & 1981; Upp, 1981; see also, Smith, 1981). One additional fault creep locality is reported herein (see section 6).

Pampeyan, et al. (1980 & 1981, the two of which are identical) delineated the Maacama fault zone in and beyond the area evaluated herein. They show "lineaments and features interpreted to be the result of recent (Holocene) movements within the Maacama fault zone." Their map is annotated, but they state (p. 5) that only "especially clear" features are noted.

In the area studied, Pampeyan, et al., depict two zones of faults. The western zone, which they indicate is the main fault zone, ranges from about ½ to 2 miles wide. Within this western zone is their "Willits fault", which they note is especially well-defined near the Mendocino County CDF Headquarters (Figure 2A). They suggest that the Willits fault extends southeastward through McGee Canyon, and ends near Pine Crest Drive Sec. 8, T.17W., R.16N., (Figure 2B). They cite Harding-Lawson Associates' (1977b) opinion that the features (which they depict as faults) in Redwood Valley between Forsythe Creek and the Russian River may be vestiges of a previous drainages pattern and not fault produced. Their "Talmage fault", also part of this western zone, appears to be well-defined by sag ponds and a trench south of Seward Creek (Fig. 2B). They show much of the terrain along the western fault zone as landslides.

The second fault zone Pampeyan, et al., identify lies along the eastern side of Redwood Valley (Fig. 2B). They note that these "lineaments... lack characteristic young fault features." The faults in this eastern zone, along with several other faults in the western zone, lack any annotations to indicate why Pampeyan, et al, concluded that recent movement might have occurred along them.

Upp (1981) has also compiled a map of the Maacama fault zone (Fig. 2A and 2B). He not only identified many geomorphic features present along the various faults, but also attempted to indicate how certain he was that Holocene movement had occurred along each segment. The overall width of the zone of faults he shows ranges from ¼ to slightly more than 3 miles; however, all of the faults he believes are probably (greater than 50% certainty) or certainly (greater than 85% certainty) of Holocene age lie in a fairly narrow zone less than ½ mile wide. He shows all other faults as possibly Holocene (20 to 50% certainty). Upp reports (Appendix A, p. 12) that evidence of Holocene activity was exposed in exploration trenches across two sag ponds (Sec. 9, T. 17N., R. 13W.), but does not discuss this evidence in the preliminary copy of ~~his report~~ parts of his report currently available to us.

Upp shows several faults located well away from the main active fault zone. However, he also indicates that these "faults" may reflect older faulting (e.g., the faults east of Redwood Valley) or may be non-tectonic in origin (the swales southeast of McGee Canyon).

A comparison of Upp's (1981) map with that of Pampeyan, et al. (1980; 1981) reveals that both generally agree on the location of the main active trace (Fig. 2A and 2B, see also Section 5). Both show faults along the traces Upp depicts as probably or certainly Holocene, although the faults depicted differ in detail.

Some of the faults located away from the main zone also largely coincide, and Pampeyan, et al, and Upp even qualify their conclusions in similar fashion (e.g., that the features between Forsythe Creek and the Russian River may be erosional in origin). Still other faults are unique to each map.

5. Air Photo interpretation.

USDA (1963) and NASA (1972) aerial photographs were interpreted for the purposes of verifying the evidence of Holocene movement along the faults delineated by Upp (1981) and Pampeyan, et al. (1980; 1981) (see my annotations on Fig. 2A and 2B). Clear evidence of recent (Holocene) faulting was observed only along a relatively narrow zone of faults (highlighted in green on Fig. 2A and 2B).

Much of the study area consists of Franciscan bedrock, which includes resistant bodies of greenstone and sandstone (as well as other rock types) and classic Franciscan melange. The main active fault zone mostly traverses landslide-mantled melange terrain. In several places, either the faults have not propagated through the landslide deposits or the diagnostic geomorphic features indicative of Holocene faulting have been obliterated by downslope movement. Even so, features suggestive of Holocene fault movement are sometimes present in the landslide area, although some of these features may have been created wholly or partly by landslide movement.

South of Seward Creek (Fig. 2B) the fault appears to be well-defined. Three sag ponds are present in this area, indicating that Holocene movement has probably occurred. It is highly unlikely that these pond-filled depressions have been caused by landslide movement. North of Seward Creek the fault appears less well-defined. Forsythe Creek appears to deflected by the fault, but the stream has recently shifted its course as noted on the topographic base. The fault could not be followed with any certainty across the flood plain of Forsythe Creek.

To the north (Figure 2A) the fault crosses landslide terrain. Many of the features noted could be the product of landslide movement. However, the linearity and continuity of the features highlighted in green in Sections 22 and 36 (T 17N, R 13W) strongly suggest that they result from recent fault movement. Conversely, the features noted in Sections 16 and 26 (T 17N, R 13W) probably are the result of landslide movement or lateral spreading. Just southeast of the Mendocino County CDF Headquarters the fault appears to be well-defined. Several closed depressions are present along the main recently active trace suggesting that Holocene movement has occurred. East and north of the Headquarters the main trace could not be delineated with certainty due to the forest cover. Holocene movement may have occurred in this area along one or more of the northwest trending faults delineated by Upp (1981) and Pampeyan, et al. (1980; 1981).

Except as noted above and on Figures 2A and 2B, many of the faults and lineaments delineated by Upp (1981) and Pampeyan, et al. (1980: 1981) lack good evidence of Holocene fault movement. Many of the features they cite as evidence for recent faulting (e.g., linear ridges, swales, notches, benches, etc.) could be produced or enhanced by erosion or landslide movement. Several of these "faults" are short, are sometimes confined to a single geologic unit (e.g., alluvium), and lack geomorphic features such as deflected drainages and closed depressions. Therefore, it appears that several of the "faults" mapped by Upp and Pampeyan, et al. are not Holocene, and some of them may not actually be faults. Even the longer "faults" depicted, such as those bounding Redwood Valley, lack evidence that strike-slip movement has occurred along them during the Holocene. All of the features identified by Upp and Pampeyan, et al., to justify delineating a fault zone through and southeast of McGee Canyon, could have been produced by stream erosion without any Holocene fault movement.

Annotations documenting my observations are shown on Figures 2A and 2B. I have basically verified some of the faults mapped by Upp and Pampeyan, et al., and have added only those features which are probably the result of Holocene faulting that they overlooked.

6. Field data.

A reconnaissance of the area was conducted on July 15 and 16, primarily to field check selected areas for fault creep. One such locality was found along Walker Road (old U.S. 101, Section 32, T 18N, R 13W) where a zone of cracks in asphalt, consisting of two orders of left-stepping en echelon fractures, was noted (Figure 2A). The zone trends N 20° W, and is aligned with a small linear valley to the south and a right-laterally deflected drainage to the north. Open cracks within this three- to four-foot wide zone indicate that about 1 cm of extension has occurred since the roadway was constructed.

Cracks were observed at several other sites but no clear pattern that would demonstrate that right-lateral fault movement had occurred (as opposed to landslide movement or damage from expansive soils) was noted.

7. Seismicity.

Dames and Moore (1977) conducted a detailed study of the seismicity along the Maacama fault. They report that relatively complete records and locations of earthquakes greater than Magnitude 2.5 are only available for the period since about 1962. They state that the apparent lack of recorded earthquakes less than Magnitude 3.5 north of Willits is probably related more to the detection capabilities of the U.S.G.S. seismic networks than to the lack of seismicity.

Dames and Moore directed their efforts at detecting microearthquakes along the Maacama fault zone. While the seismographic record from 1906 to 1976 does not clearly show a zone of greater seismic activity along the Maacama, the microseismic survey, conducted over a 72-day period ending September 23, 1977, does appear to document seismic activity associated with the Maacama fault. The zone of activity seems to be centered about two to three miles east of the mapped trace. Dames and Moore reported that the fault plane solutions were consistent with right-lateral, strike-slip movement. A 4.8 earthquake occurred near Willits in November 1977, just after the Dames and Moore study concluded. Simon, et al., (1978) suggested, based on UC Berkeley data, that this epicenter was located about nine miles east of the Maacama fault.

8. Conclusions.

The presence of geomorphic features indicative of Holocene movement along a narrow, fairly continuous zone of locally well-defined faults indicates that the Maacama fault (highlighted in green on Figures 2A and 2B) is sufficiently active and well-defined. As noted earlier (section 6), historic fault slip has occurred along the Maacama fault within the study area as well as to the north and south. Also, the fault appears to be seismically active.

The remaining faults and lineaments shown by Upp (1980) and Pampeyan, et al., (1980; 1981) do not appear to be sufficiently active to warrant zoning. Also, many of these remaining faults are not well defined. It appears that the criteria and methodology used by Upp and Pampeyan, et al., differed substantially from that used by Alquist-Priolo Project staff. They appear to have delineated faults along which displacement might have occurred during Holocene time. Alquist-Priolo criteria, however, is directed at zoning only those faults along which movement has most probably occurred during the Holocene.

9. Recommendations.

Those faults delineated in green on Figures 2A and 2B should be zoned. Because the meaning of the line symbols used by Upp (1981) and Pampeyan, et al. (1980; 1981) differ from those used on the Special Studies Zones Maps, the faults should be depicted and zoned as shown on Figures 3A and 3B. The locations of the faults shown were obtained from Upp (1981), Pampeyan, et al. (1981), and this FER. Therefore, these three references should be cited on the SSZ maps.

10. Investigator; date.

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July 8, 1981

TCS/map

I agree with recommendations to zone. EWH 1/26/82